

PIVOTAL TRANSITIONS – HISTORICAL AND TODAY

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ABSTRACT

The goal of this paper is to enable readers to better “design” successful transitions that move Science and Technology or Research and Development (S&T/R&D) technologies and systems into operational capabilities for users. Transitions from S&T/R&D into acquisition and operations are challenging and critical to providing capabilities to end users. Two historical examples, the Global Positioning System (GPS) and the Disaster Monitoring Constellation (DMC), are explored. Two current examples are also explored, including one from Operationally Responsive Space (ORS) which is in the early stages of transition. While transitions are necessary, transition periods are inherently challenging and dynamically changing situations. These situations must be carefully managed and led in order to succeed. Characteristics, approaches, and incentives that foster effective transitions are discussed. Understanding the transition process and the communities involved allows one to maximize the chance of successfully moving an S&T/R&D development into an operational capability supporting end users.

1. INTRODUCTION & CONTEXT

1.1. The Broader Process

The process of developing and transitioning new capabilities from Science and Technology or Research and Development (S&T/R&D) into acquisition and user operations is part of a larger process. This process includes multiple communities, organized into five groups for the purpose of discussion in this paper. Figure 1 depicts the path an identified user need has to follow to be satisfied by an operational capability. The identified need, depicted as an orange ball, requires significant momentum in order to “roll through” the process with enough energy to overcome the challenges presented by each community. Each phase is led by a particular community and the energy needed to get through that phase is depicted as a resistance hump in Figure 1.

To some extent these challenges are in place to prevent immature technologies or inappropriate capabilities from transitioning into acquisition and operations.

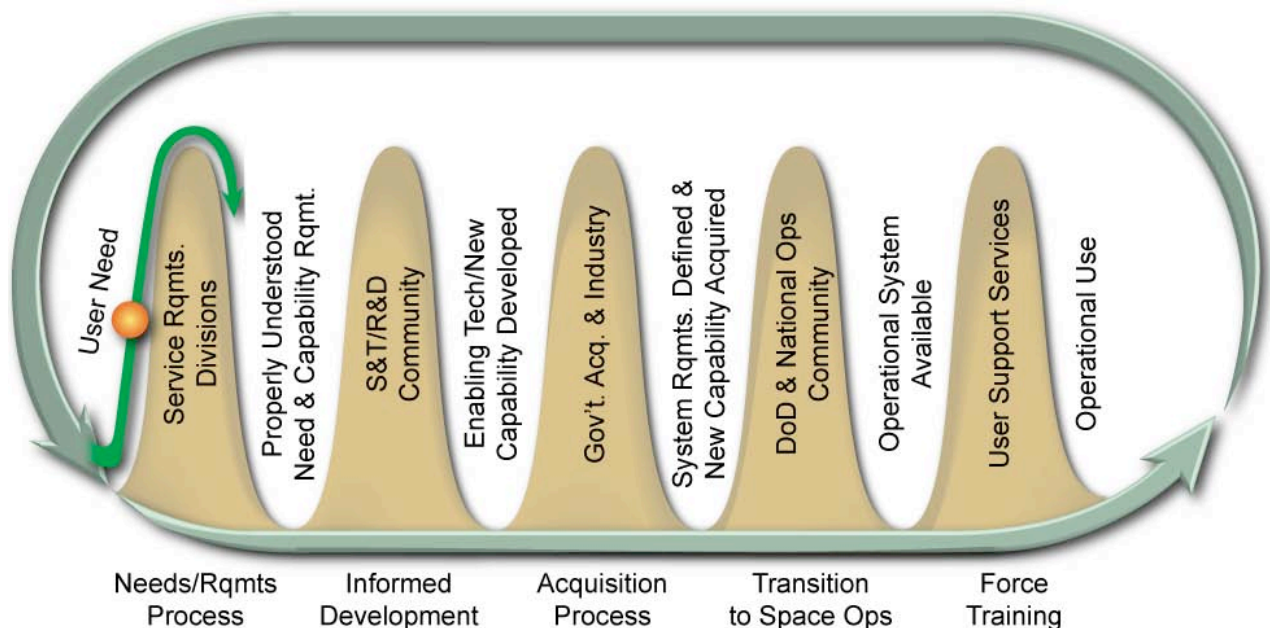


Figure 1. Process of Transitioning a User Need into an Operational Capability for Users

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Even mature and well developed technologies need some method of prioritization simply due to the limited resources available to acquire and operate any system. So this process does provide valuable vetting and prioritization. However, the amount of energy required to get through the process can be significantly reduced by designing an appropriate transition which considers each community, their processes, and the specific S&T/R&D capability being developed.

The community labels given in Figure 1 are somewhat Department of Defense (DoD) oriented, but the core elements of this process are similar for other government and commercial developments. Generally, current operational needs are identified in the field and future needs are identified by the Services doing analysis and simulations to find gaps in future operations. In each case, these needs and gaps are typically prioritized annually and made known to the S&T/R&D communities.

Many of these needs require long term S&T/R&D projects to develop appropriate capabilities. Indeed, some of these operational needs are somewhat generic, e.g., continue increasing ship speed while reducing fuel consumption, and result in ongoing S&T/R&D research in applicable areas that provide multiple transitions at logical development points over time. The core functions of the S&T/R&D community are to properly understand the users' needs, including the users' operating environment, and to develop technologies and systems to a maturity level appropriate for acquisition and user operations. However, the move of an S&T/R&D development into the acquisition community requires far more than technical considerations to succeed. While well prioritized S&T/R&D focus areas help to produce opportunities in line with acquisition and operations priorities, the transition into acquisition is the first time the potential capability and specific S&T/R&D development receive real scrutiny and vetting based on limited operational resources. To some extent, there is a bit of timing "luck" involved. In the United States DoD, major projects tend to be considered in the budgeting process every two years and the selection of specific projects is affected by highest prioritized needs at the time and by the overall budget available for the planning cycle. The acquisition process is also the first time specific system-level requirements are written. These system-level requirements generally attempt to provide new operational systems and capabilities using relatively mature technologies. Once a system has been acquired and made available to the operational

community, it still has to be accepted by the operational users. Operational user acceptance is directly related to the overall operational need for the capability, the training of the users to effectively operate the system, the system's performance, and the ease of use.

Other notable factors affecting the transition between any of the communities in this process are social communications, differing points of view, and differing incentives. Any of these three factors alone can prevent a successful transition, in some cases completely trumping the technical, performance, and financial merits of a specific project. Ideally, personnel in each community would have an excellent understanding of each community and what motivates them. Practically, however, most people will stay largely within their own community, performing the many tasks needed and stay in their area of expertise, largely unaware of the others. Fortunately, a relatively small percentage of people in each community can greatly improve the transition of developments into user capabilities provided they have this cross community understanding and ability to communicate.

The process shown in Figure 1 is not fully serial as the figure implies and many communities need to communicate with each other at any given time in this process. For example, S&T/R&D personnel often need to work directly with the operational end users to refine their development in order to convince the acquisition community to procure it. Still, the figure does properly show the primary community responsible for a given capability as it matures over time.

1.1. Push versus Pull and Sustaining versus Disruptive

Specific capabilities developed can be the result of a "push" from the S&T/R&D community or a "pull" from the operational community. The process of transition is affected by whether the situation is "push" or "pull". A push situation occurs when a new technology enables a capability not previously envisioned by the operational community. Sony is a company known for innovation and is often in the situation of pushing new capabilities, enabled by new technologies, into the market. The Sony Walkman is an example of a technology push that created a user demand for its new capability. A pull situation occurs when the operational community requests logical upgrades to existing systems or new capabilities to counter new situations. The desire to increase ship

speed while reducing fuel consumption or the urgent need to improve body armor to protect against Improvised Explosive Devices are user pull examples.

Understanding whether an S&T/R&D development is a “sustaining technology” or a potentially “disruptive technology” is also important. These terms and ideas are explained in “The Innovator’s Dilemma”¹. Technologies that provide understood, logical upgrades to existing capabilities and users are generally considered sustaining technologies. Technology developments that potentially bring a completely new capability, not yet understood or sought by current users, may become a disruptive technology.

The examples given in this paper will occasionally highlight important transition characteristics and approaches that should be selected based on whether the specific S&T/R&D development is a push or pull situation and whether it is a sustaining or disruptive technology.

1.2. Scope

This paper focuses on transition from S&T/R&D into acquisition and user operations. All the examples given in this paper are for space systems, although many of the processes and communities are identical for ground, sea, air, and space systems. The process for identifying and prioritizing needs is not discussed in depth, nor is the transition into operations. This paper describes the overall process, transition challenges, several examples, and a framework for designing a successful transition. The goal of the paper is to enable people to better design transitions that successfully move S&T/R&D developments into operational capabilities for users.

2. CHALLENGES AND FRAMEWORK

2.1. Challenges of the Process

Any user need working its way through the process depicted in Figure 1 will face many common challenges. The magnitude of these challenges, which are case-by-case, effectively raises or lowers the size of the resistance hump that must be overcome in each community to proceed to the next phase. Below are some common challenges and associated questions worth understanding.

Technical – What Is It and When Is It Ready?: Every S&T/R&D development has some enabling technology which must be matured to a level appropriate for acquisition and operations. Technology Readiness Levels (TRL) and the process for advancing levels are well understood throughout the space industry. The magnitude of technology development needed can only be determined on a case-by-case basis. More difficult cases will raise the S&T/R&D community hump in Figure 1 and increase the effort required to get through this phase; simple technology development will lower the hump. One artificial constraint to watch out for is the misapplication of TRL or heritage requirements sometimes imposed by the S&T/R&D and acquisition communities.

Needs and Requirements: The overall process can be greatly streamlined or hindered based on the level of understood user need for a capability. The following questions help characterize the users’ demand or lack of demand: Is the technology development a technology push or user pull situation? Does it address a well understood need? Is the development an evolutionary sustaining situation or a potentially disruptive situation? If successful, will this capability satisfy a niche or broad user community? Does a formally documented requirement exist for this capability, or is it still only an identified need?

Fit Into Existing Operational Systems and Infrastructure: The cost to implement a new development and the amount of user training required is often directly related to how well the S&T/R&D development fits into existing systems. This makes logical sense. However, sometimes surprising hindrances may emerge if an existing system, entrenched in the acquisition or operational communities, feels threatened. Seemingly illogical resistance to new and improved systems can occur due to conflicting incentives such as large numbers of personnel being funded by the existing program, individual promotions being tied to the well being of existing programs, or the need for users to change already approved operational procedures.

Social Interaction and Buy-In Between Communities: Multiple challenges potentially exist here. The most basic being the ability and opportunity for communication between communities. The same language is often used with very different meanings based on the point of view of people within each community. For example, a scientist saying a technology “is ready” may be completely misleading to

¹ “The Innovator’s Dilemma”, Clayton Christensen, 1997

an operational user asking if a technology “is ready for use”. The alignment of incentives across communities is also a challenge. For example, the S&T/R&D community may have incentives to transition all of their developments into acquisition, while the acquisition community may have incentives to prevent cost growth by minimizing new capabilities. A potentially disabling situation occurs when personnel in the various communities have become convinced the others do not understand their situation or do not share their core principles and values. This can prevent all but the most urgent user needs from getting through the process.

Acquisition Specific Challenges: The acquisition community is the gate keeper for procuring systems that provide operational user capabilities. Several challenges are rightly imposed to verify a given user need and its associated S&T/R&D technical development are properly vetted and prioritized before spending any of the always limited funding resources on them. When bringing a technical development forward, the S&T/R&D community should be aware of the acquisition community’s need for a credible cost and schedule baseline and the broadness (or limitations) of the industrial base capable of producing the related operational capability. Finally, for space systems, the trend toward acquiring large, complex systems inherently limits transition opportunities. Fewer spacecraft and fewer launches may quickly limit and narrowly focus the development and transition of many new space based capabilities.

2.2. Framework to Evaluate and Design

Some framework is necessary to coherently evaluate and design a successful transition from an S&T/R&D development into acquisition and operational use. This framework will be used to understand the characteristics, approaches, and incentives of a given transition. This framework provides a summary from which “keys to success” must be identified or created. These keys to success must be a short list of two to four items that can be easily understood by the proverbial man on the street. Arguably, if the fundamental capability and the keys to successful transition cannot be easily explained, then the transition is unlikely to occur, especially if the transition requires costly systems to realize its capability.

The framework will use the categories of *Need*, *S&T/R&D Technology*, *Transition*, *Acquisition*, and

Operational Use. The four transition examples in the next section of this paper will use these categories to organize and succinctly summarize the main traits of their transitions process.

Need: A clear headed evaluation of the operational need and priority for the potential capability.

S&T/R&D Technology: Identification of the critical enabling technologies, their level of maturity, and component or system development approach up until acquisition.

Transition Period: Description of the drivers to move the S&T/R&D development into acquisition and operations. Examples include strong user need, exceptional business factors, methodical transition of evolutionary capability, etc. Ultimately people make all of this happen, so one should determine if a transition is relying on exceptionally strong leadership or on long-term working level champions.

Acquisition: Description of the situation and factors affecting procurement or desired for procurement.

Operational Use: Description of the situation and factors affecting user adoption. For example, does the transition leverage existing ground systems and users or require substantial user training?

3. TRANSITION EXAMPLES

Four examples are provided in this section to feature various situations, characteristics, and approaches to transition. The first historical example is the Global Positioning System (GPS), which provides a mature example of a once radical new capability developed and now completely transitioned to both military and commercial user operations. A second historical example, the Disaster Monitoring Constellation (DMC), provides an example of rapid transition made possible largely due to an exceptional business model. A current example of a wind sensor, WindSat, whose capability is in the process of being transitioned to the NPOESS weather satellites, provides an example of an evolutionary capability development and transition approach. Another current example of spacecraft bus standards developed for Operationally Responsive Space provides a look at a transition in an early, pre-acquisition phase of the process.

3.1. Global Positioning System, GPS

The fundamental GPS capability, providing precision navigation and time, is now well known worldwide and will not be discussed here. The GPS provides an extremely mature transition example in that the system has transitioned through the process twice. Multiple acquisition block buys have been procured and transition to operations has occurred to the military operational community as well as to commercial consumer users. Referring to Figure 1, the orange ball would be depicted as having run up and over all the resistance humps multiple times and now would be sitting at the far right in the operational use area. Figure 2 shows a timeline of the development and transition of the GPS system which is summarized below.

Need: Navigation and time, especially at sea, is an age old need with its utility well understood. Still, the level of precision navigation and time were not formal requirements during the S&T/R&D phase.

S&T/R&D Technology (~1963-1978): Critical enabling technologies were atomic clocks, advanced spacecraft buses, and digital signal waveforms. Maturing these capabilities required over 15 years of S&T/R&D development at the component and system level. The last S&T/R&D spacecraft was developed, integrated, and tested at the Naval Research Laboratory, with the

Rockwell Company, who had won the Block-1 Air Force procurement contract, physically present on-site.

Transition Period (1978-1985): The primary driver through this transition period was the user need. Stable acquisition leadership was in place and responsible for system and mission success. The Block-1 procurement was largely a transition period into full acquisition and initial military operations.

Acquisition (1985-Present): The requirements and system design were Jointly defined, which assured the system would support a broad user base. The acquisition organization was in a smart buyer situation with critical technologies proven and sound operational prototype baselines for procurement. The prime contract winner of the Block-1 award maximized the S&T/R&D benefits by working on-site at the NRL for the final operational prototype and at Vandenberg AFB for the launch.

Operational Use (1985-Present): GPS has had two operational user transitions. The first was to military users from the mid-1980s through the 1990s. The second transition was to commercial and consumer users from 1993 to present. GPS was a new capability, requiring new ground equipment and significant user training. These factors, coupled with the time needed to get 24+ satellites on orbit for official Initial

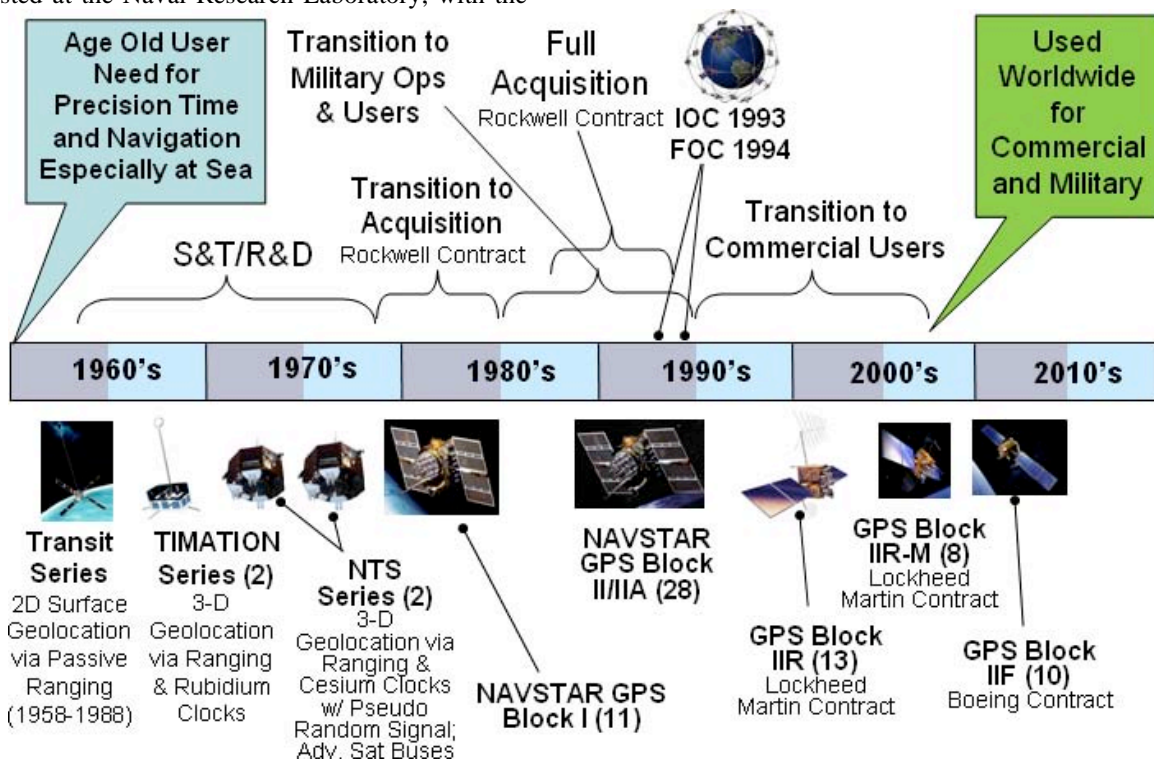


Figure 2. Global Positioning System (GPS) Example

Operational Capability in 1993, explain the relatively long transition and user adoption periods.

Keys to Success: A few primary keys to success can be identified for GPS. Several enabling technologies allowed a fundamentally new capability. A strong user need existed and was amplified by Jointly defining the requirements and system design to assure a large user base was supported. A smart buyer acquisition situation existed due to the government led prototyping of enabling technologies. Finally, transition from S&T/R&D to acquisitions was made as seamless as possible by having the Block-1 prime contractor on-site for the development and launch of the final operational prototype.

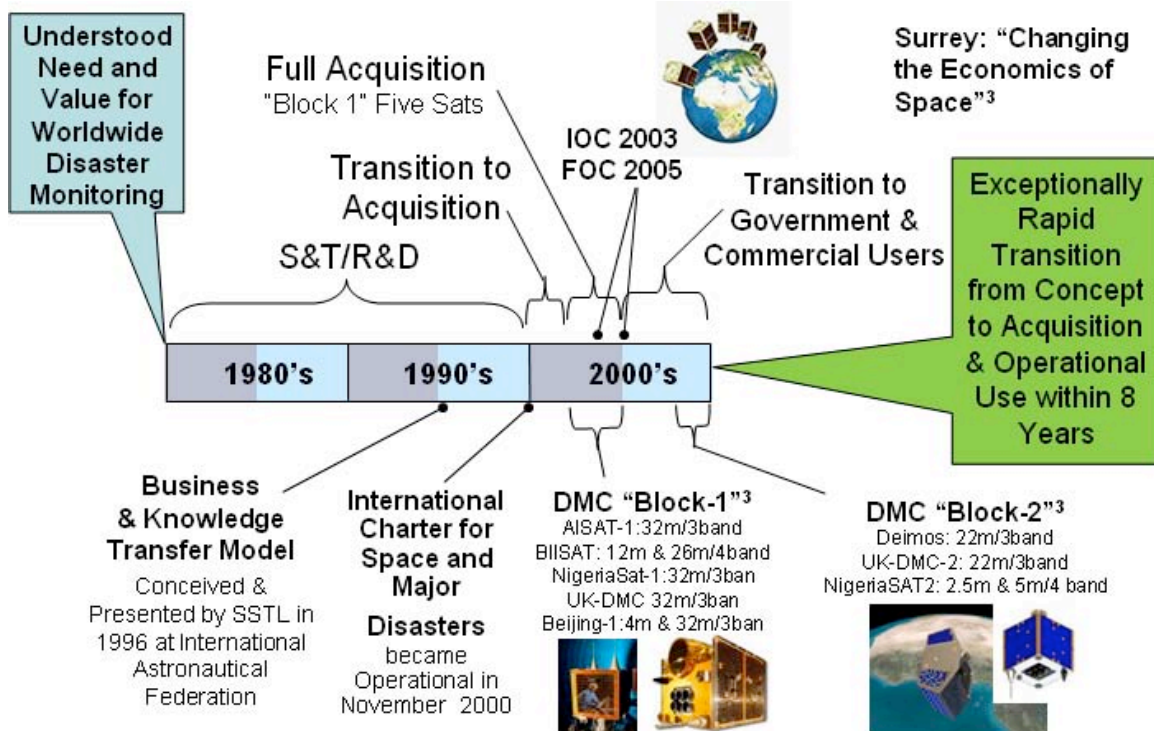
3.2. Disaster Monitoring Constellation, DMC²

The DMC is an international constellation of earth observation satellites providing daily images for applications including global disaster monitoring. Similar to the GPS example above, the DMC provides a mature example of a system that has transitioned through the entire process with a second block buy, or

constellation update, currently in an acquisition cycle. Referring to Figure 1, the orange ball would be depicted as having run up and over all the resistance humps working its way down the final hump as more and more users become aware of and trained to use the DMC system. Figure 3 shows a timeline of the development and transition of the DMC system which is summarized below. The transition to acquisition and operations is notably rapid.

Need: Worldwide disaster monitoring is the core mission need. In addition, several of the participating countries have or had a need to increase their knowledge of space systems and become space faring nations.

S&T/R&D Technology (~1980-2000): Critical enabling technologies were low cost and light weight spacecraft components allowing a 100kg microsatellite to perform 32m imaging in three bands with a 600km swath width. This micro-satellite class further allowed reliable, low cost launch of constellations. The Internet was another enabling technology highly leveraged for DMC. Arguably, the S&T/R&D development phase for DMC



³: SSTL Website <http://www.sstl.co.uk> used for quote and DMC satellite technical information

Figure 3. Disaster Monitoring Constellation (DMC) Example

² Surrey Satellite Technologies LTD Website, <http://www.sstl.co.uk>

could be claimed to have started in 1996 (not 1980) when the business and knowledge transfer model was conceived for international constellations and focused development started for this constellation.

Transition Period (2000-2002): An exceptional business model, providing high value and low barriers to entry, made this transition so rapid. The ability for a country to obtain the benefits of the full DMC constellation by providing just one micro-satellite and its associated operations was of great value to several countries. DMC has some disruptive technology characteristics in that DMC created a fundamentally new capability and market of new users.

Acquisition (2002-2005): Members of an international consortium, including Algeria, Nigeria, the United Kingdom, China, and Turkey, each provided a spacecraft and its operations in support of the constellation. The unique knowledge transfer arrangements allowed seamless transition and rapid acquisition using existing Surrey prototypes and flight designs. A second block buy, or constellation upgrade, is already underway, with three more satellites launching in 2008 and 2009. Spain is a partner beginning with this constellation upgrade. The incentives of the participating countries were well aligned with the mission of disaster monitoring. Acquisition and operations roles and responsibilities were carefully assigned to avoid common international sensitivities, such as foreign spacecraft control, which greatly simplified and streamlined the official international agreements necessary for acquisition and operations.

Operational Use (2003-Present): The DMC operational user adoption has also been rapid. Because of the broad international participation, the system began with a large set of users looking to use the DMC capability. To further speed user adoption, the DMC constellation was designed such that the data collected are compatible with existing and familiar LANDSAT image processing software. This leveraging gave the entire LANDSAT community immediate access to the DMC data with little to no training needed.

Keys to Success: The primary keys to success for DMC were the exceptional business case, use of near ready technology, and high leverage of the existing ground Internet and LANDSAT image processing systems. Finally, the unique knowledge transfer arrangements added value to participating members while also

providing rapid and seamless transition into acquisition and operations.

3.3. Wind Sensor on NPOESS³

The National Polar Orbiting Operational Environment (NPOESS) is the United States national program providing weather and environmental monitoring from space. The first launch is scheduled for around 2013 with a total of four satellites currently planned. Wind speed and direction at sea is a formal requirement and has long been a user need. A prototype sensor named WindSat was built and launched in 2003 to demonstrate wind direction capability, in addition to wind speed. This prototype provided sound system requirements and led to the Microwave Imager/Sounder (MIS) sensor being prepared for acquisition and flight on NPOESS satellites C2, C3, and C4.

Referring to Figure 1, this wind sensor is just over half way through the process. The orange ball would be best depicted as having run up, over, and just beginning down the acquisition hump. As contracts are awarded and the MIS sensor is built, the orange ball will work its way down the acquisition hump until the new sensor is acquired and installed on a flight NPOESS satellite. Figure 4 shows a timeline of the development and transition of the wind sensors leading up to and including WindSat and MIS on NPOESS. Unlike the previous two historical examples, this capability is evolutionary. Adding wind direction is the next logical sustaining step in the operational system. A formal requirement does exist, however the additional wind direction capability is a moderate need when prioritized against other meteorological needs such as altimetry. The transition of a wind speed and direction sensor onto the NPOESS satellites provides an example transition of an evolutionary operational system capability improvement in process now.

Need: There is a long term need for wind speed and direction at sea. Wind speed has been provided for decades. A formal, unmet requirement for speed with direction existed for years. The requirement was unmet for a long time partially due to technology limitations, but also due to other meteorological requirements with higher priority than wind direction.

³ NPOESS Website, <http://www.ipnoaa.gov>

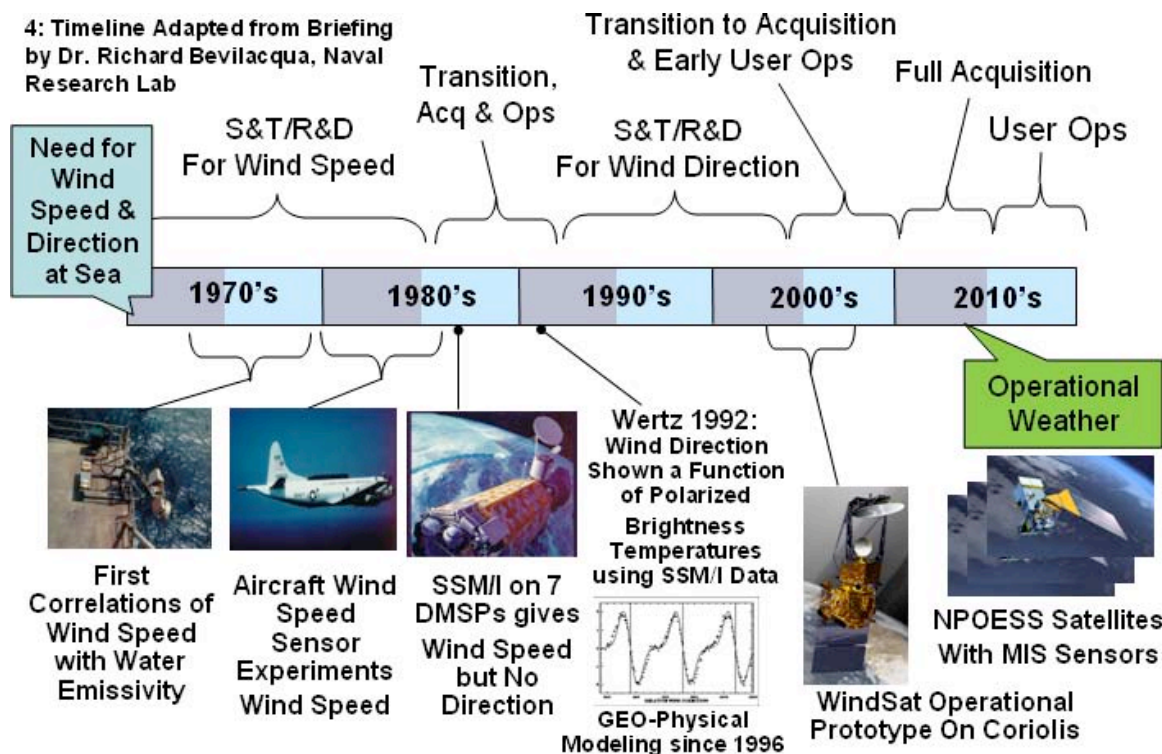


Figure 4. Wind Speed and Direction Sensor, WindSat, Transition to NPOESS Example

S&T/R&D Technology (1992-2004): Critical enabling technologies were polarimetry algorithms, low signal-to-noise radio frequency detection antenna and receivers, and low cost high wicking heat pipes. The S&T/R&D phase prototyped key components, an integrated system, and flight data processing and dissemination.

Transition Period (2004~2014): Wind direction is the next logical evolution of the operational system which is already providing wind speed. The new capability provides an existing user base with a new and improved wind product. This long term development and periodic operational system enhancement cycle has been accomplished largely by stable, working level champions in the meteorology and space communities.

Acquisition (2008~2020): Government led prototyping of WindSat has the acquisition community in a smart buyer situation. Credible technical, cost, and schedule estimates are understood. The NPOESS program is in the process of planning the MIS sensor procurement strategy and beginning acquisition to support the MIS sensor flight on NPOESS satellites C2, C3, and C4.

Operational Use (~2014-??): The MIS sensor data will be sent to an existing meteorology user base and

community. The MIS data will leverage the processing software and data dissemination systems at the Fleet Numerical Meteorology and Oceanographic Center which currently processes and disseminates WindSat and other meteorological data. For these reasons the operational user adoption should be very rapid once MIS is launched.

Keys to Success: The primary keys to success for WindSat and MIS are expected to be the enabling polarimetry technology, long term champions, smart buyer acquisition, and existing operational users familiar with the product.

3.4. ORS Spacecraft Bus Standards⁴

First, a small digression before discussing this example. The process shown in Figure 1 was originally assembled during the formation of the "Plan for Operationally Responsive Space" submitted to Congress in April 2007. One of the intents of this plan is to organize the Joint ORS Office such that members from each of these communities – service requirements, S&T/R&D, acquisition, space

⁴ "Standards for Responsive Small Satellites", GP Sandhoo et al., ESA 4S 2008

operations, and COCOM user support – are in the ORS Office, allowing for informed communication, rapid decision making, and quick transitions.

Now to the ORS Bus Standards example. A four phase effort was undertaken to develop spacecraft bus standards supporting the recognized need for modularity to rapidly tailor and launch ORS space capabilities. This process is fully described in the “Standards for Responsive Small Satellites” paper in this ESA 4S 2008 conference. For this paper the following highlights are relevant. Broad government and industry acceptance was identified early on as critical for success. Therefore, a four phase process was set up with MIT/LL, AFRL, NRL/APL, and SMC each leading a different phase of the standards development. The timeline of this process is shown in Figure 5. Phase 1, led by MIT/LL, provided an analytical basis for the class (size, weight, power, cost, etc.) of spacecraft bus deemed operationally useful. Phase 2, led by AFRL, provided a bus for a Low Earth Orbit imaging mission with an emphasis on modular design. This bus provided valuable data for performance requirements and cost. Phase 3, led by NRL/APL, assembled a broad industry and government team to formally document sound ORS Bus Standards for an initial procurement. Phase 3 factored in available standards and case studies from throughout the industry. An Integrated System

Engineering Team and a Business Team were formed to address technical and business factors on an even basis. Phase 3 also developed a flight prototype bus to develop, evaluate, and mature the documented ORS Bus Standards. Phase 3 is concluding and the transition to acquisition is beginning for possible acquisition starting in fiscal year 2009.

The ORS Bus Standards are early in the transition process. The S&T/R&D community has prepared sound technical, cost, and schedule baselines as well as worked broadly with industry so that many companies are ready to design and produce buses to these standards. The acquisition community has not yet adopted these ORS Bus Standards or solidified any procurement. Referring to Figure 1, the orange ball would be most of the way up the acquisition hump, but not yet over it. Unlike the previous examples, the decision to acquire has not yet occurred, nor does a formal requirement exist for these bus standards.

Need (2002-2004): The need for spacecraft bus standards and modularity for an ORS system was recognized in 2002 and documented in 2003. However, multiple standards and modularity approaches are theoretically possible. Requirements for ORS system modularity and rapid response exist but a specific formal requirement for ORS Bus Standards does not exist.

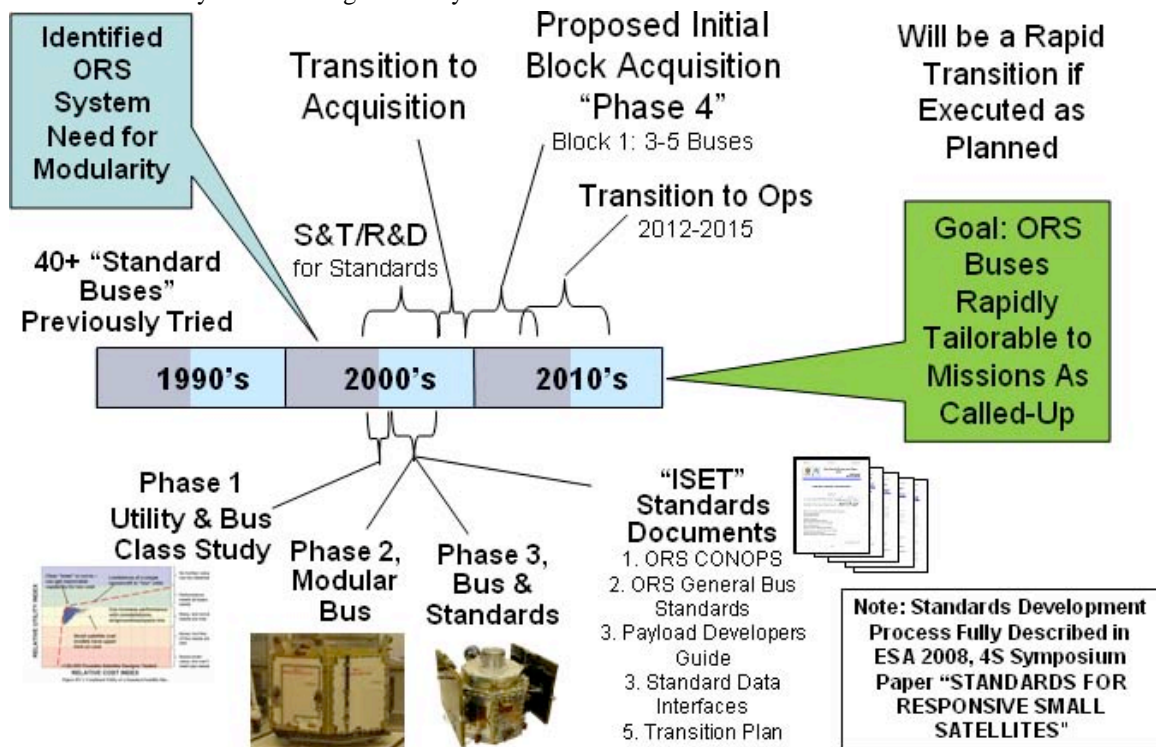


Figure 5. ORS Spacecraft Bus Standards Example

S&T/R&D Technology (2005-2008): Enabling bus and payload technologies developed over several decades now allow operationally useful spacecraft in the Small-Sat class (100kg-500kg). This phase was set up from the start to seamlessly bridge the S&T/R&D development with acquisition procurement. Integrated government and industry teams were formed to address both technical and business aspects of the standards development. Standards were formally documented and ORS flight bus prototypes were built to evaluate and mature these documented standards for acquisition.

Transition Period (2008~2009): The Business Team developed a formal transition plan for these ORS Bus Standards. This plan is socialized and being considered by the ORS Office and related acquisition organizations. The plan originally emphasized high level leadership, but turnover of leadership and acquisition personnel has required working level champions to keep the acquisition transition viable.

Acquisition (2009-2015): A broad industrial base is ready to design and build buses to the ORS Bus Standards. This industrial base is well informed because ten spacecraft bus manufacturing companies formally participated in the standards development. The acquisition organization is in a smart buyer situation with formal documentation and multiple prototypes establishing a sound baseline. A procurement of some volume (3-5 minimum) is essential for these bus standards to be used and have a positive impact on the ORS system capability.

Operational Use (~2012-??): The ORS Bus Standards support the formally documented initial Concepts of Operations (CONOPs) for ORS. While these standards are compatible with the CONOPS, the transition into operational use (in this case meaning into an operational depot, assembly, and command and control) will depend heavily on the ORS infrastructure which is still being defined and expected to emerge over the next few years.

Keys to Success: The primary keys to success for these ORS Bus Standards are expected to be the recognized need for ORS system modularity, broad industry buy-in, a smart buyer acquisition situation, and a volume procurement.

3.5. Additional Examples in the Appendix

The Appendix includes a table of Navy and NRL S&T/R&D developments that have transitioned to acquisition and operations. The Appendix also includes a list of ORS technology initiative projects. These projects are component and subsystem level technology developments that are complete or nearly complete. This list of ORS technology projects is provided for community awareness and to encourage international relationships and partnerships. As always, any international technology transfer is subject to ITAR requirements.

4. CHARACTERISTICS OF SUCCESSFUL TRANSITIONS FROM S&T/R&D

While each transition must be addressed on a case-by-case basis, there are common characteristics to successful transitions. Three things are true in all cases: 1) the critical enabling technologies must be identified and high risk items developed to the point where sound requirements for technical, cost, and schedule can be written; 2) the need must be understood, credible, and substantial enough to apply acquisition and operational resources; and 3) it is people that make the process happen within and across each community. There can be many case-by-case differences in the *Need*, *S&T/R&D Technology*, *Transition Period*, *Acquisition*, and *Operational Use* framework that collectively summarize the situation and transition plan, but the collective set of characteristics and approaches must be self consistent to succeed.

5. CHARACTERISTICS OF SUCCESSFUL ACQUISITIONS⁵

The following characteristics are known to foster successful acquisitions. All may not be present for success, but many will need to be.

Leadership: Leaders should be responsible for mission success, not just a short phase of the program. Leadership must foster a working environment of mutual respect and trust. Leadership must set program objectives and make decisions that are within the realm of possibility or the whole team will fall into a dysfunctional cycle because they know that regardless of their efforts the mission cannot be accomplished.

⁵ Section is largely adapted from multiple briefings, papers, and discussion by and with Mr. Bill Collins and Mr. Edward Senasack.

Government is an Informed and Experienced Buyer: To receive a good product, any buyer must understand the capability and system being requested well enough to describe it properly and follow the design and build through completion. Government experience and the existence of credible baselines for technical, cost, and schedule requirements is essential to a new space systems acquisition.

Trusted Government Technical Lead: Acquisition program offices obviously need support from technically experienced personnel who are objective third parties. These personnel should support and be motivated by mission success, not profits or action items (excessive action items are a great source of unnecessary work in many programs).

Contracting: Contracts must have appropriate incentives balanced across performance, cost, and schedule. Acquisition organizations should use award fee contract incentives to encourage finding and fixing problems early. Finally, industry expertise in design for production, maintenance, and networked subcontracting should be used as much as practical.

Apply Life Cycle Management: Substantial cost and capability risks can be overlooked if the new system and operations are not considered over the entire life cycle.

Use Proper Environment for High Risk Developments: The development of advanced technologies and high risk system items should be performed in an environment without conflicting incentives. Specifically, when the technology is not mature enough to confidently write system requirements with a sound technical, cost, and schedule baseline, the development should not be done in an acquisition environment. High risk developments are more successful in not-for-profit environments with close government, industry, and academia development relationships. Time and material style funding to milestone points tends to keep the incentives balanced and allows the needed flexibility to rapidly change development and design direction as problems are encountered and understood.

6. CONCLUSIONS

Many challenges exist to transition S&T/R&D technical development into acquisition and ultimately end user operations. For space systems, the decision to procure and operate a system is rarely a trivial one and opportunities are limited. There is no magic formula, as the appropriate combination of characteristics and











approaches must be determined on a case-by-case basis for each transition being considered. However, case studies help to identify successful combinations for various situations. Applying an understanding of the process and communities involved then allows one to design a transition plan that avoids inconsistencies and common traps, thereby maximizing the chances of providing end user capabilities.

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APPENDIX

EXAMPLES OF NAVY TRANSITIONS FROM S&T/R&D TO ACQUISITION AND OPERATIONS

1956	Blossom Point "BP" Ground Station		1 ST U.S. Ground Station. "Mini-Track" Capability became NAVSPASUR and Now the "Space Fence"
1958	Vanguard Satellite & Rocket		Nation's Oldest Orbiting Satellite. 1 ST Solar Cells. Rocket Transitioned to Newly Formed NASA & Created Foundation for Delta Rockets.
1960 -1971	GRAB & POPPY		1st U.S. Reconnaissance Satellite (GRAB) 1st U.S. ELINT System (POPPY –declassified 2005)
1967 -1977	Transit/TIMATION/NTS		Transit -1 st Navigation System from APL Timation/NTS from NRL became 1st Global Positioning System (NAVSTAR GPS)
1978 - present	FLTSATCOM, UHF Follow -On, & MUOS		Navy Satellite Systems Tactical Communications. MUOS is Next Generation System in Development for First IOC in ~2010.
1987 -1993	Tactical Reporting and Processing TRAP/TRE		Global Tactical Broadcast System Lead to TRAP/TRE and IBS
1996	Onboard Processor		Largest Supplier of Tactical Direct Downlink Reporting
1998	Geosat Follow -On (GFO)		Ocean Height From Space
2003	WindSat (on STP's Coriolis)		Wind Vector From Space, Transitioning to NPOESS Microwave Imaging Sounder (MIS)
2004 -2010	TacSat -1, TIE Payload, & TacSat -4 for ORS		Development & Transitions In Progress. MDA, UHF Comms -on-the-Move, Data -X, ORS Bus Standards.

Note: Only UNCLASSIFIED Systems Shown Above

ORS TECHNOLOGY INITIATIVE

RECENTLY COMPLETED PROJECTS READY FOR COMPONENT OR SUBSYSTEM TRANSITIONS

The table below is provided for community awareness and to encourage international relationships and partnerships. As always, any international technology transfer is subject to ITAR requirements.

Company	Project Name
COMPLEX CATEGORY (\$2M-\$5M)	
Ball Aerospace	L-Band Synthetic Aperture Radar
Goodrich	Airborne EO/IR Sensor for ORS
Assurance Technology Corporation	RF Digital Payload (RDP) Software Reprogrammable Payload
MODERATE CATEGORY (\$500K - \$2M)	
Composite Technology Devices	Lightweight Large Composite Reflector for ORS
SEAKR	Reprogrammable Space Network Interface Card (SNIC)
Interface Control Systems (ICS)	Autonomous Tasking and Checkout of Responsive Space Platforms
Johns Hopkins University Applied Physics Laboratory (JHUAPL)	WISPER – Wafer Integrated Spectrometer
Raytheon	CIRCE – Advanced Hyperspectral Payload
BASIC CATEGORY (\$0-\$500K)	
SpaceDev	Corri – Combined Optical, Radar, Radio
Microsat Systems (MSI)	UIE – Universal Interface Electronics
AMAssT	Enhancing Space Control with Structured Light Sensor
General Dynamics (AIS)	HIGHRISE – Hi Res Imaging Sensor and Exploitation
L3 SSG-Tinsley	Optical Mirror Manufacturing Techniques for ORS
Johns Hopkins University Applied Physics Laboratory (JHUAPL)	JHUAPL – Self Healing CD&H (for commercial electronics use in space)
InnoFlight	IP Transceiver Experiment
Design Net Engineering	Software Interfaces and Test Bed
AFRL	Star Tracker & IMU miniaturization and integration
Vulcan Wireless	UHF Tactical Data Link for ORS